Theatre of Dreams: Beyond the LHCb Phase 1 Upgrade

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The Physics Potential of Upstream Tracking

M. Martinelli (EPFL)

Outline

- Physics with Upstream Tracks
- Current Upstream Tracking Status
- Possible Improvements
- Ongoing Work
- Conclusions

Physics with Upstream Tracks

Lots of Potential

- **There is many physics out there that could be done with Upstream tracks (if they had good momentum resolution…)**
- **Multi-Body decays: $B_s^0 \rightarrow D_s^+ D_s^-$, $D \rightarrow hhhh$**
- **Charm physics: $D^{*+} \rightarrow D^0 \pi^+$**
- **b-baryons: $\Sigma_b^+ \rightarrow \Lambda_b^0 \pi^+$**
- **See Sheldon's talk for more**

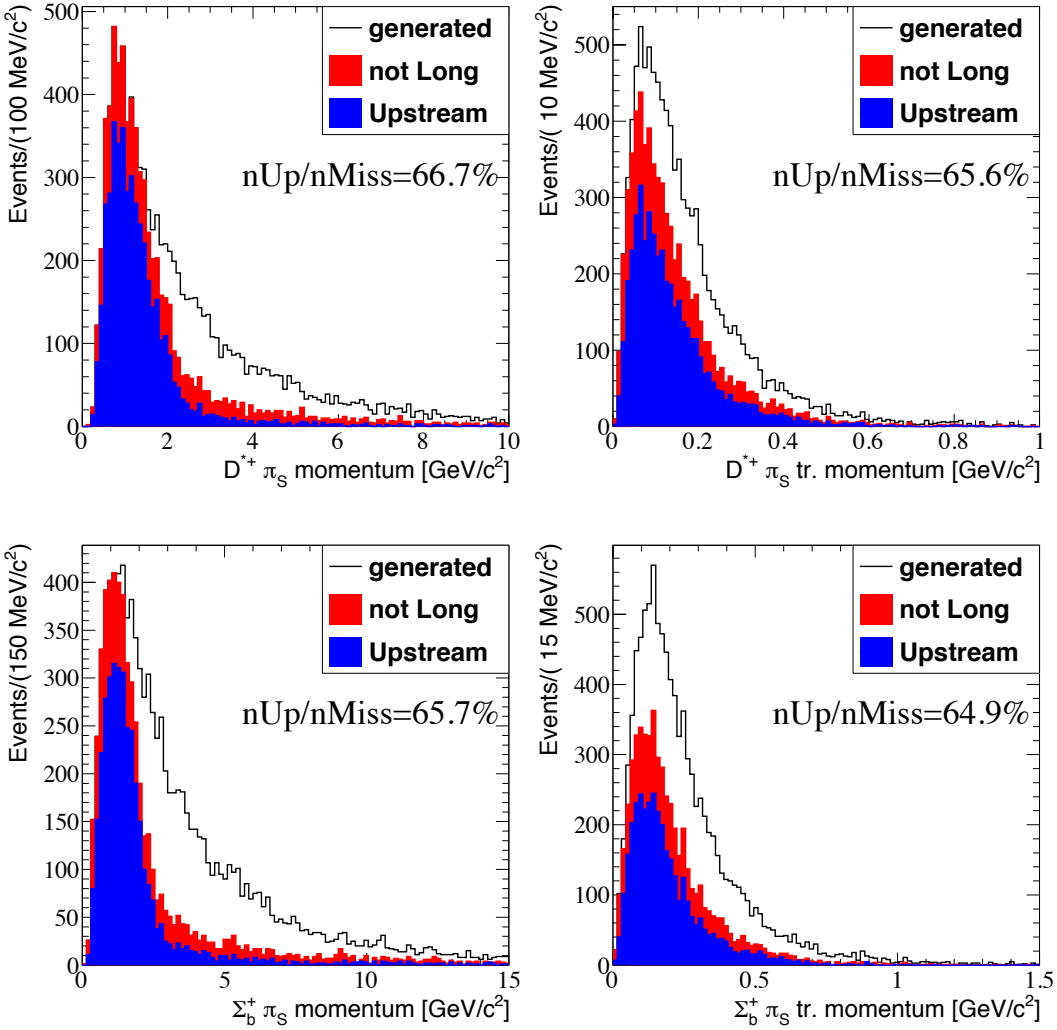
The Study

- **Used IMCReconstructible tool on LHCb MC samples**
- **Some definitions (from…)**
  Long: 3r+3phi Velo clusters and 1x+1stereo clusters in each of the 3 seed stations
  Upstream: 3r+3phi Velo clusters and 3 TT clusters
- **Studies:**
  Momentum distributions
  Potential decay efficiency

Potential with Upstream Tracks - Soft pions

Momentum Distributions

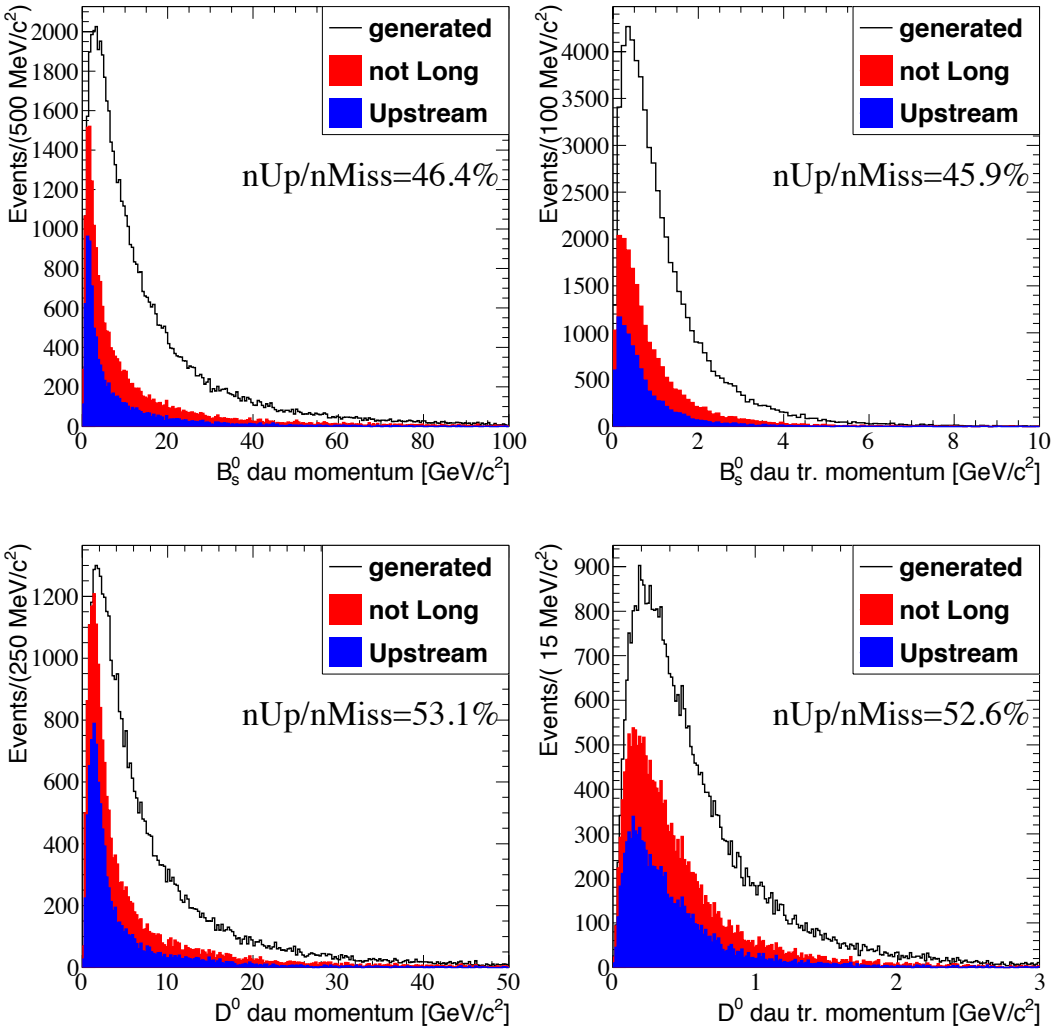
- **$D^{*+} \to D^0 \pi^+$ and $\Sigma_b^0 \to \Lambda_b^0 \pi^+$ considered**
- **Plot soft pion momentum distribution for**
  - generated (white filled)
  - missed by Long (red filled)
  - potential Upstream (blue filled)
- **Most of the missing particles have momentum < 2 GeV/c**
- **Could be significantly recovered with Upstream (~65%)**



Potential with Upstream Tracks - Multibody

Momentum Distributions

- **$B_s^0 \to D_s^+ K^- \pi^+ \pi^-$ and $D^0 \to K^+ K^- \pi^+ \pi^-$**
- **Plot momentum distribution of final state particles**
  - generated (white filled)
  - missed by Long (red filled)
  - potential Upstream (blue filled)
- **Momentum distribution slightly harder than before**
- **Still a significant part of the spectrum is missed by Long tracks**
- **Could be significantly recovered with Upstream (~50%)**



Potential with Upstream Tracks - Some Numbers

Efficiency

- Previous numbers can be misleading to estimate efficiency since at least one track that passes the selection is needed
- The table shows the efficiency of signal candidates that are reconstructible if all the final state particles are reconstructible as Long or Long+Upstream

Decay	ε_{Long}(%)	$\varepsilon_{Long+Upstream}$(%)	Increase(%)	factor
$B^0_s \to D_s^+ K^- \pi^+ \pi^-$	10.8	33.5	22.7	3.1
$\Sigma_b^0 \to \Lambda_b^0 \pi^+$	44.9	80.6	35.7	1.8
$D^{*+} \to D^0 \pi^+$	31.9	76.6	44.7	2.4
$D^0 \to K^+ K^- \pi^+ \pi^-$	11.4	40.1	28.7	3.5

Upstream Tracking Status

VeloTT Algorithm

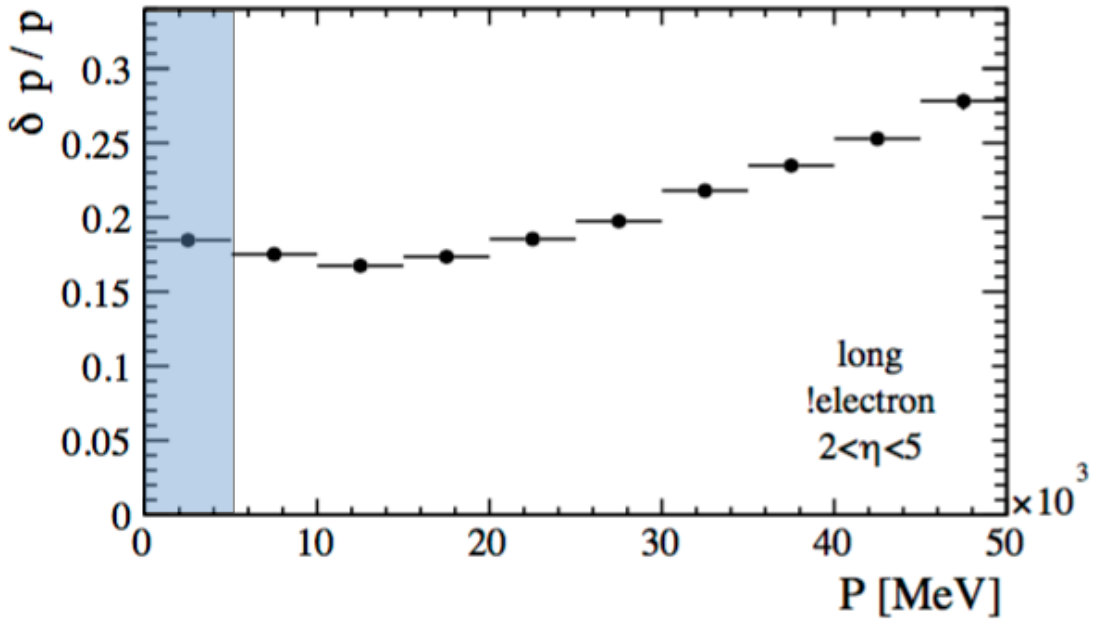
- **Starts from Velo seeds, extrapolates in TT and looks for corresponding hits**
- **Not used in Run1**
- **Improved in Run2 and used in default reconstruction as a seed for the Forward in HLT1**

Thanks to B. Storaci and E. Bowen - LHCb-PUB-2013-023

Quite fast: used in HLT1

Momentum resolution 15-20%

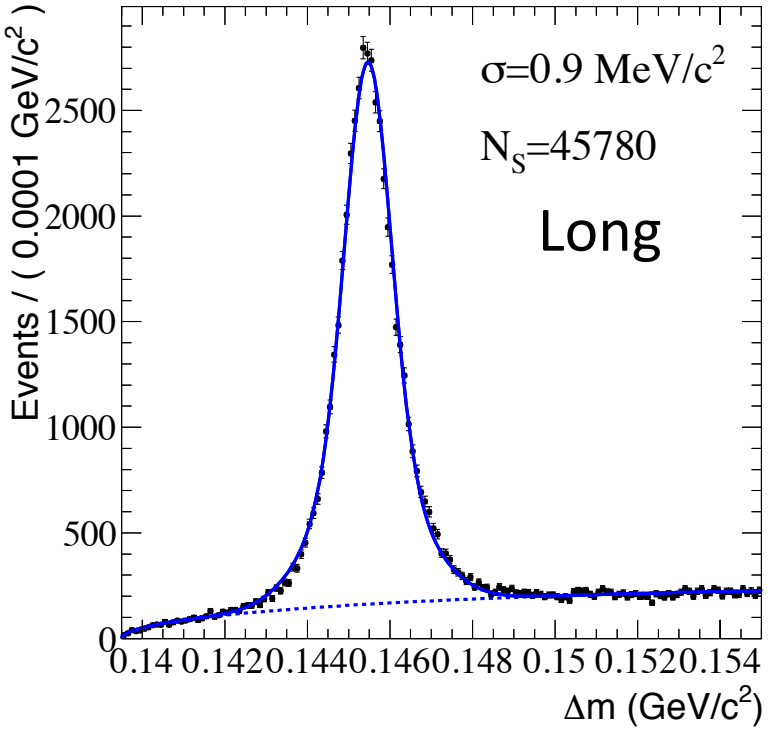
Efficiency ~65% (not Long)

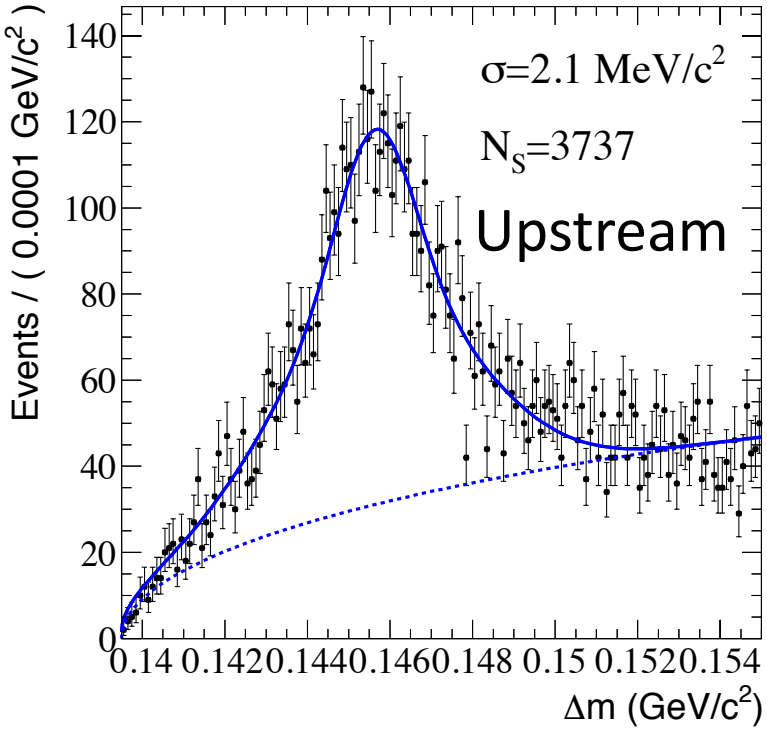


Upstream Tracking Performance - Run1

Old VeloTT Algorithm

- Data from CharmCompleteEvent - Reco14/Stripping21
- Starting from $D^0 \rightarrow K^-\pi^+$ candidate, reconstructing D^{*+} using both Long and Upstream tracks
- Efficiency seems very low (processed the same number of events)

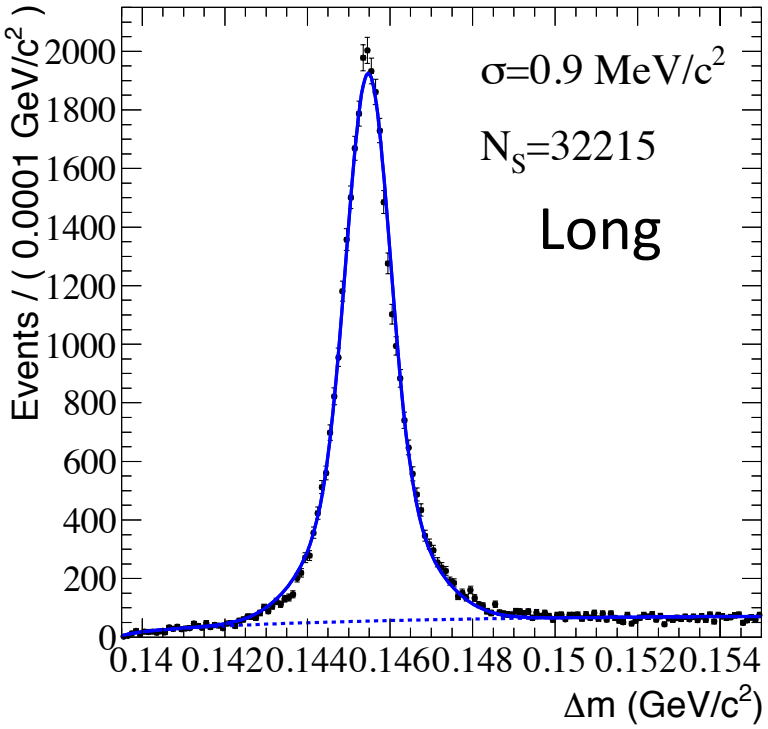


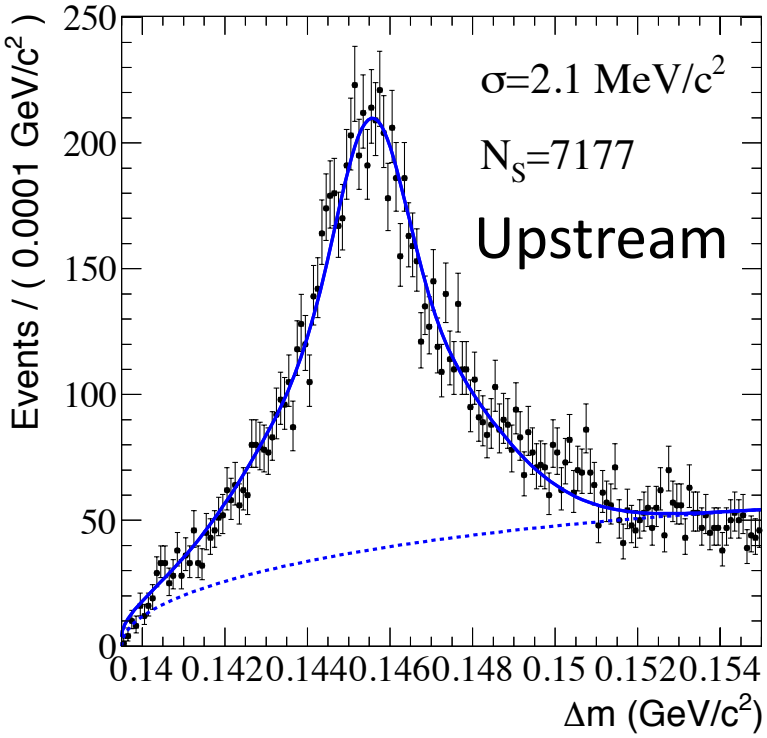


Upstream Tracking Performance - Run2

New VeloTT Algorithm

- Simulation from $D^0 \to K^-\pi^+$ - Reco15/Stripping23 (Jun2015 conditions)
- Starting from $D^0 \to K^-\pi^+$ candidate, reconstructing D^{*+} using both Long and Upstream tracks
- Similar resolution as 2012 but higher upstream reconstruction efficiency (x2.5)

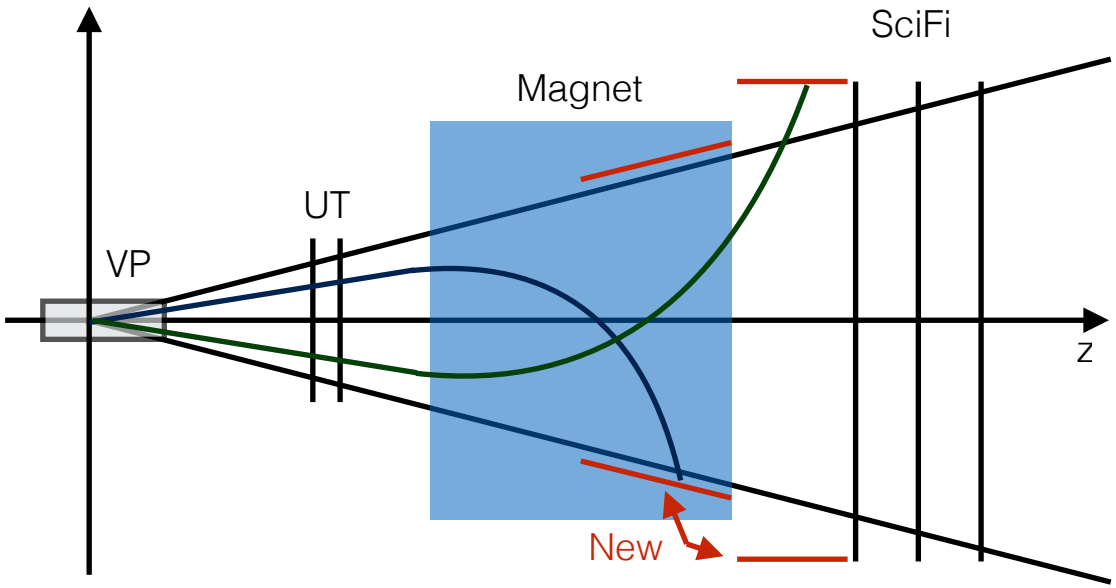




Possible Improvements

Hits after Magnet Kick

- New stations after the magnetic field kick could improve momentum resolution



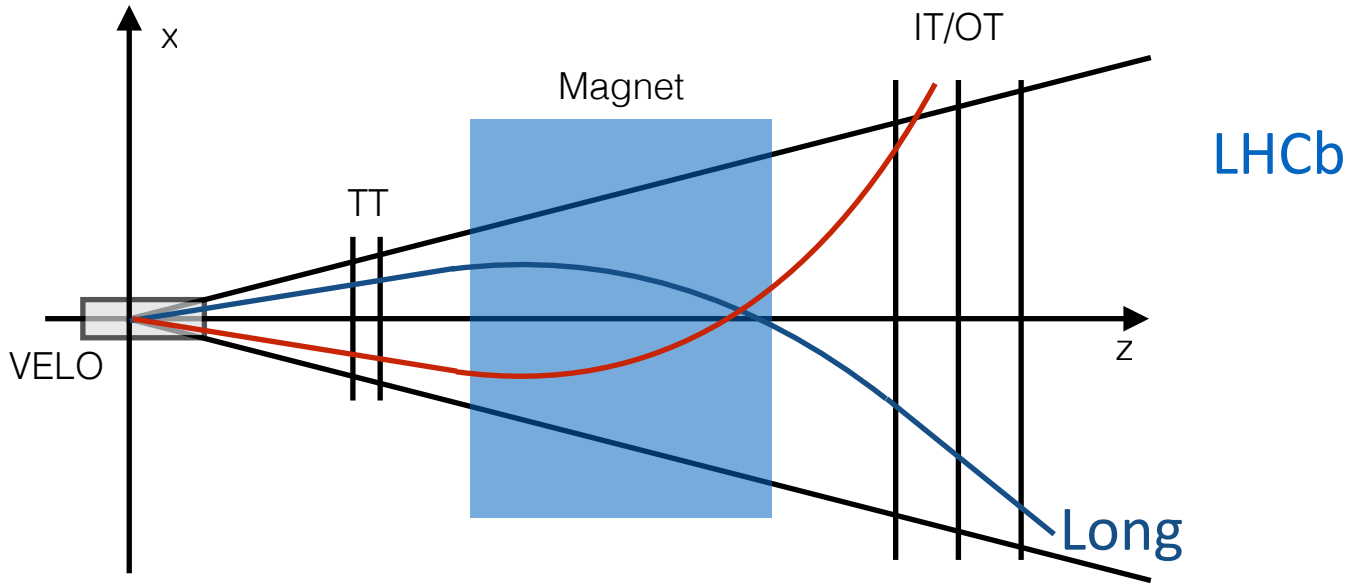
LHCb Upgrade

Ongoing Studies

Tracking

- **VeloTT Efficiency**
  Should be carefully studied to check the correspondence with reconstructible and reconstructed tracks
- **Check Momentum Resolution improvements**
  1. Simulate hypothetical detector response
  2. Perform a proof-of-principle study
- **(A very short list of) Questions:**
  a. Is a single layer enough?
  b. How much the resolution would improve?
  c. What are the detector requirements?
- **Unfortunately still ongoing - stay tuned!**

A Proof of Principle - Upstream+



Performance Gain in Current LHCb?

- The red track above is currently not reconstructed in LHCb
- A tracking algorithm can be written to reconstruct it and measure its momentum
- This could have a direct impact in current LHCb reconstruction

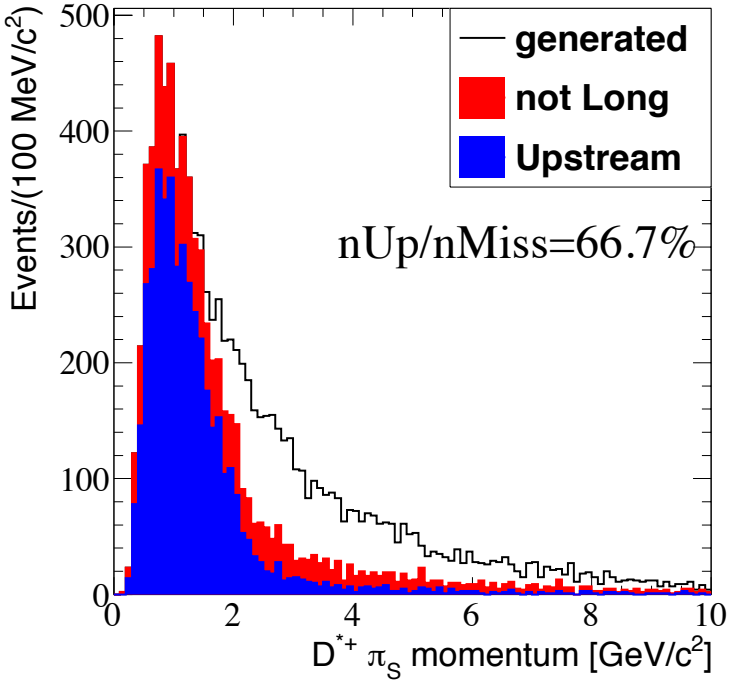
Ongoing Work

- Study π^+ from $D^{*+} \rightarrow D^0\pi^+$ in data and MC to implement a reconstruction algorithm
- Basic idea: start from VeloTT track; use momentum estimate to open a search window; add hits; refit.

Conclusions

Low-Momentum Physics

- **Low-momentum tracks may increase our efficiency**
  maybe not as much as a 2x luminosity, but they can help
- **Upstream tracks currently not used in LHCb reconstruction**
  it's anyway important to try to get the best from our detector
- **A plan is made to study whether adding stations inside the magnet could be useful**
- **Outcome could be helpful for current detector already (Upstream+)**



Is a factor 2 efficiency gain possible?